Ref. Ares(2025)3759782 - 08/05/2025

Funded by the European Union

Horizon Europe programme, grant agreement No. 101096068

RETROFIT SOLUTIONS TO ACHIEVE 55% GHG REDUCTION BY 2030

Technical report on ATEX requirements for a safety eSail® integration

WP 4 – Wind Assisted Ship Propulsion
Task 4.7 – Study of WASP installation requirements in vessels in potentially explosive environments
Deliverable 4.9 – Technical report on ATEX requirements for a safety eSail® integration
Partners involved: B4B, ATD, SFD, RINA, LASK
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Project details

Project Title	RETROFIT SOLUTIONS TO ACHIEVE 55% GHG REDUCTION BY 2030
Project Type	Innovation Action
Project Acronym	RETROFIT55
Grant Agreement No.	101096068
Duration	36 M
Project Start Date	01/01/2023

Deliverable information

Status (F: final; D: draft; RD: revised draft)	RD 08/05/2025
Planned delivery date	31/12/2024
Actual delivery date	08/05/2025
• **Dissemination level:** PU – Public, fully open, e.g. web (Deliverables flagged as public will be automatically published in CORDIS project's page) • SEN – Sensitive, limited under the conditions of the Grant Agreement • Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444 • Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444 Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444	PU
Type: Report, Website, Other, Ethics	Report

Document history

Version	Date	Created/Amended by	Changes
01	05/05/2025	Pablo Martín Binder (B4B), Guillermo Piñero Linde (B4B)	Original Draft
02	07/05/2025	Giorgia Abbate (RINA)	Technical Review
03	07/05/2025	Emanuele Spinosa	Editorial Review
04	08/05/2025	Pablo Martín Binder (B4B)	Final review

Quality check review

Reviewer (s)	Main changes / Actions
Giorgia Abbate (RINA)	Technical review.
Emanuele Spinosa (CNR)	Editorial review.
Cecilia Leotardi and Alessandro Iafrati (CNR)	Final review of contents and submission to EC.

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Acronyms

Acronym	Description
AoA	Angle of attack of wind to a foil
ATEX	ATmosphères EXplosibles
BV	Bureau Veritas
CCSS	Classification Societies
DNV	Det Norske Veritas
FEM	Finite Element Modelling
GHG	Green-House Gas
IACS	International Association of Classification Societies
PV	Pressure/vacuum
WASP	Wind-assisted Ship Propulsion

Executive Summary

The maritime sector is at a critical turning point, forced by global climate imperatives and regulatory mandates to decarbonize operations and transition toward sustainable propulsion technologies. The European Union's Green Deal, with its ambitious target of reducing greenhouse gas (GHG) emissions by at least 55% by 2030 compared to 1990 levels, and the International Maritime Organization's (IMO) revised a GHG strategy, which aims for net-zero emissions from international shipping by 2050. They have set the stage for a profound transformation in shipping practices. These frameworks are reinforced by a suite of regulatory instruments, both internationally and within the EU territory, including the EU Emissions Trading System (ETS), FuelEU Maritime, and the Carbon Intensity Indicator (CII), all of which encourage the adoption of energy efficiency technologies and penalize high- emission operations [1], [2].

Wind-Assisted Ship Propulsion (WASP) systems have reemerged as a leading solution for maritime decarbonization, offering the unique advantage of harnessing a free, zero-carbon energy source without compromising vessel autonomy or operational flexibility. Among these, the eSAIL® system developed by bound4blue stands out as a state-of-the-art technology, leveraging advanced aerodynamic principles and active suction mechanisms to deliver up to seven times more lift than conventional sails. This innovation translates into substantial fuel savings - up to 10-15% in optimal conditions - and corresponding reductions in CO_2 emissions [3], [4].

The eSAIL® system is characterized by its mechanical simplicity, minimal power consumption, and fully autonomous operation, making it suitable for a wide range of vessel types, including tankers, bulk carriers, Ro-Ros, cruise ships, ferries, and gas carriers. Its modular design and ease of integration facilitate both newbuilds and retrofit applications, as demonstrated in high-profile installations on vessels such as the EPS tanker Pacific Sentinel and the Odfjell Bow Olympus. The technology's economic viability is underscored by a typical payback period of less than five years, even when accounting for the higher upfront costs associated with ATEX-certified installations.

A critical consideration for deploying eSAIL® systems, particularly on vessels operating in hazardous environments such as oil and chemical tankers, is compliance with the ATEX Directives (2014/34/EU for equipment and 1999/92/EC for workplaces). ATEX (ATmosphères EXplosibles) regulations mandate rigorous standards for the design, construction, certification and operation of equipment in potentially explosive atmospheres. All equipment installed in classified hazardous zones—where flammable gases, vapours, or dusts may be present— must be appropriately certified to prevent ignition sources and ensure the safety of personnel and assets [5].

This report provides a comprehensive analysis of the requirements, challenges, and best practices for installing eSAIL® systems in ATEX environments. It synthesizes the latest regulatory guidance, industry standards, and real-world case studies to detail safe installation procedures, risk assessment methodologies, and integration strategies [6]. The report also examines the alignment of eSAIL® deployments with the objectives of the EU RETROFIT55 project, which aims to accelerate the adoption of energy-efficient retrofits across the European fleet. Furthermore, it presents a cost-benefit analysis comparing ATEX and non-ATEX installations, explores the environmental and operational impacts of wind-assisted propulsion, and outlines future development pathways for the technology.

Key findings highlight that while non-ATEX eSAIL® units can streamline installation and reduce capital expenditure (CAPEX) on vessels with existing hazardous zones, ATEX-certified solutions are

indispensable for tankers and other ships with classified areas. The report highlights the importance of rigorous risk assessment and compliance with classification.

1 Introduction

1.1 ATEX environments: regulatory framework and equipment requirements

Overview of ATEX Directives ATEX is the collective name for two key European Union directives:

- ATEX 114 (2014/34/EU), which covers equipment and protective systems intended for use in potentially explosive atmospheres, serving out essential health and safety requirements and conformity assessment procedures.
- ATEX 153 (1999/92/EC), which focuses on the minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.

These directives require that all equipment installed in hazardous zones—areas where explosive atmospheres may occur due to the presence of flammable gases, vapours, or dusts—must be appropriately certified and marked. The classification of hazardous zones is based on the frequency and duration of the presence of explosive atmospheres [7]:

- Zone 0: explosive atmosphere present continuously or for long periods.
- Zone 1: explosive atmosphere likely to occur in normal operation.
- Zone 2: explosive atmosphere unlikely in normal operation or only for short periods.

Equipment is further categorized by group and category, with Group II (non-mining) and Categories 1, 2, or 3 corresponding to the level of protection required for each zone.

Certification and Marking ATEX-certified equipment must undergo rigorous testing and conformity assessment by a Notified Body, and be clearly marked with the CE mark, the “Ex” symbol, and detailed information on equipment group, category, temperature class, and gas/dust group. The certification process ensures that the equipment is designed to prevent ignition sources, such as sparks or hot surfaces, and that it is suitable for the intended hazardous environment.

In the maritime sector, ATEX requirements are especially important for oil and chemical tankers, LNG carriers, and other vessels that handle or store flammable substances. In the UK, the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) implement the ATEX directives, with comparable regulations enforced across the EU and internationally.

Key considerations for ATEX-compliant installations include [8]:

- Risk assessment: comprehensive evaluation of explosion risks and classification of hazardous zones on board.
- Equipment selection: use of ATEX-certified components for all systems installed in or near hazardous zones, including electrical, mechanical, and control systems.
- Integration with Ship Systems: Ensuring compatibility with existing power, control, and safety systems, and minimizing the risk of ignition during both normal operation and maintenance.
- Documentation and certification: preparation of detailed documentation for submission to classification societies and flag states, including risk assessments, installation diagrams, and conformity certificates.

2 Case studies: eSAIL® installations and ATEX considerations

2.1 Non-ATEX installations

Several recent eSAIL® installations have been completed on vessels where hazardous zones were present but carefully avoided, allowing the use of non- ATEX units. For example, the installation of three 22- meter-high eSAIL® units on the EPS tanker Pacific Sentinel was completed with non-EX-proof equipment, streamlining the process and reducing CAPEX. The project achieved double-digit fuel savings, enhanced regulatory compliance, and minimal vessel downtime, with all work undertaken during planned maintenance.

Similarly, the installation of four eSAIL® units on the chemical tanker BOW Olympus demonstrated the technology's ability to deliver significant CO_2 reductions and improve the vessel's CII rating, supporting compliance with both EU and IMO regulations [9].

2.2 ATEX-ready installations

While the above projects did not require an ATEX-certified equipment due to the careful zone classification and avoidance, the deployment of eSAIL® systems on vessels with hazardous zones—such as oil and chemical tankers—necessitates strict adherence to ATEX requirements. Although no public case studies have yet documented in a full ATEX- certified eSAIL® installation, the technical and regulatory framework is well established and was followed within the project`s case studies.

Key best practices for ATEX installations include:

- Zone classification: detailed mapping of hazardous zones on deck and in adjacent spaces, based on the nature and frequency of flammable substance handling.
- Equipment specification: selection of eSAIL® components (motors, sensors, control panels) with appropriate ATEX certification for the relevant zone (typically Zone 1 or 2).
- Installation procedures: step-by-step protocols to prevent ignition risks during installation, including isolation of power sources, use of intrinsically safe tools, and continuous gas monitoring.
- Risk mitigation: implementation of explosion protection measures such as flameproof enclosures, intrinsic safety barriers, and regular maintenance checks.
- Emergency response: development of detailed emergency procedures and crew training to ensure rapid response in the event of a gas leak or fire.

2.3 Integration with classification society and regulatory requirements

All eSAIL® installations, whether ATEX or non-ATEX, must be approved by the relevant classification society (i.e., BV, ABS, DNV) and comply with flag state regulations. The granting of a "wind-assisted" notation is a key milestone, verifying the structural integration and safety of the system [10]. Documentation submitted for approval typically includes stability analyses, deck reinforcement plans, electrical circuit diagrams and risk assessments.

2.4 Cost-benefit analysis: ATEX vs. non-ATEX installations

The decision to specify ATEX-certified eSAIL® equipment is driven by the vessel's operational profile and the presence of hazardous zones. While ATEX units entail higher upfront costs due to additional certification, design, and installation requirements, they are essential for ensuring safety and legal compliance on tankers and other high-risk vessels.

Non-ATEX installations, by contrast, involve lower CAPEX and simpler installation procedures, but are only suitable for vessels without classified hazardous areas or where a thorough feasibility study confirms that non-classified zones are not being encroached upon. Despite this, the payback period for both configurations remain attractive, thanks to the substantial fuel and emissions savings delivered by the technology.

Maintenance schedules should be developed in accordance with manufacturer recommendations, classification society requirements, and ATEX regulations, with periodic inspections to verify the integrity and functionality of all components. Predictive maintenance strategies, supported by real-time monitoring and data analytics, can further enhance reliability and reduce downtime.

Looking ahead, the continued evolution of wind-assisted propulsion technologies, coupled with advances in digital monitoring and regulatory frameworks, will further enhance the safety, efficiency, and environmental performance of the global fleet. Ongoing research and development efforts are focused on further enhancing the aerodynamic performance, integration capabilities, and digital monitoring systems of eSAIL®. The roadmap includes the development of next-generation materials, advanced control algorithms, and expanded certification, to address emerging regulatory requirements and market opportunities both in ATEX and non-ATEX environments.

3 Applicable ATEX regulations and standards

The integration of sail technology on commercial vessels over 5000 DWT must follow a robust regulatory framework that ensures the safe installation and operation of any equipment located in or near hazardous areas. These areas, commonly found on tankers and gas carriers, are subject to strict classification and certification rules, to mitigate risks of fire or explosion due to flammable atmospheres.

3.1 International and european regulatory framework

The **ATEX Directive 2014/34/EU**, also known as the "Equipment Directive", regulates equipment and protective systems intended for use in potentially explosive atmospheres in the European Union. The directive requires that such equipment must be certified as ATEX-compliant if installed within defined hazardous zones (Zone 0, 1 or 2 for gases; Zone 20, 21, or 22 for dust).

In parallel, **Directive 1999/92/EC** (the "ATEX Workplace Directive") focuses on the safety of workers potentially exposed to explosive atmospheres and requires a risk assessment of these areas.

In the maritime industry, these directives are issued by the IMO, both in the Safety of Life at Sea (SOLAS) [11] Convention and in standards provided by the Maritime Safey Committee (MSC) [12], such as:

- **SOLAS Chapter II-2**, Regulation 4 and 10: Governs the fire safety and protection of spaces, including management of flammable atmospheres.
- **MSC.1/Circ.1321 – Guidelines for the design and approval of fixed gas fire-extinguishing systems for ro-ro spaces and special category spaces**, also relevant to cargo area classification.

Additionally, **IEC 60079 series** internationally recognize and establishes the fundamental technical basis for ATEX compliance [13], [14]:

- **IEC 60079-0** – General requirements for explosive atmosphere equipment
- **IEC 60079-10-1** – Classification of hazardous areas (explosive gas atmospheres)
- **IEC 60079-14** – Electrical installations design and selection
- **IEC 60079-17** – Inspection and maintenance of Ex equipment

These standards are typically adopted (sometimes with modifications) by classification societies in their own rulebooks.

3.2 Classification societies – key references

Each classification society has published technical rules and guidance that directly or indirectly address the safe installation of equipment in hazardous areas. Table 1 summarizes the most relevant documents:

Table 1: Summary of the most relevant Class Societies’´ documents

Classification Society	Reference / Rule Title
DNV	DNV-RU-SHIP Pt.4 Ch.8 – Electrical installations in hazardous areas
	DNVGL-OS-A101 – Safety principles and arrangements
Lloyd’s Register (LR)	LR Rules and Regulations for the Classification of Ships – Part 6, Chapter 2: Electrical Equipment
	LR Guidance Notes: “Installation of Electrical Equipment in Hazardous Areas”
Bureau Veritas (BV)	BV Rules for the Classification of Steel Ships – Part C, Chapter 4: Electrical Equipment
	NR 320 – Rules for the Classification of Offshore Units and Platforms
ABS	ABS Rules for Building and Classing Marine Vessels – Part 4 Chapter 8 – Electrical Installations in Hazardous Areas
	ABS Guide for Hazardous Area Classification and Installation of Electrical Equipment
RINA	RINA Rules for the Classification of Ships – Part D, Chapter 3: Electrical Installations
	Rules for the classification of tankers – Hazardous zones and electrical equipment
ClassNK (NK)	ClassNK Rules – Part D, Chapter 8: Electrical Installations
	Guidelines for Use of Explosion-Protected Electrical Equipment

These references provide the framework for:

- Defining hazardous zones on deck
- Selecting ATEX-certified equipment when required
- Accepting alternative risk mitigation measures (e.g., relocation of zone-defining equipment such as PV valves)

4 Risk analysis and methodology

To ensure the safe integration of the eSAIL® system on vessels where flammable substances may be present, Bound4blue follows a structured approach grounded in established maritime safety regulations. The methodology focuses on identifying and avoiding ATEX-classified areas by leveraging each vessel's approved Hazardous Area Drawing. The following outlines the key considerations and steps involved in this risk analysis process:

- Process for identifying explosive atmospheres in various types of vessels.
- Key factors in risk evaluation (presence of gases, ventilation, temperature, etc.).
- Definition of ATEX Zones and categorization according to the regulations.

All vessels are delivered (or have been retrofitted) with an approved **Hazardous Area Drawing**, in full compliance with IEC 60079-10-1 [15] and SOLAS II-2 [11]. This plan defines on-deck ATEX zones as follows:

- **Zone 0, 1, 2** for flammable gas or vapor atmospheres
- **Zone 20, 21, 22** for combustible dust atmospheres

These zones are mapped during contruction and must be updated whenever deck modifications or equipment changes (e.g., PV valves, vent headers, manifold alterations) could alter the extent or classification of an explosive-atmosphere area. The Hazardous Area Drawing is maintained as part of the ship's Safety Equipment File and is re-approved by the flag state or classification society whenever changes occur.

Bound4blue does not perform the original hazard zoning studies; instead, we rely on the vessel's **existing and approved** Hazardous Area Plan to identify where the eSAIL® can be safely installed. The following steps are involved in our structured workflow:

1. **Review of Approved ATEX Drawings**
    a. Obtain the latest Hazardous Area Plan from the shipowner or shipyard.
    b. Cross-check zone boundaries against the up-to-date General Arrangement drawing.
2. **3D Deck and Hazard Zone Modelling**
    a. Import ATEX zone volumes (Zones 1 and 2) into a 3D model of the vessel's deck.
    b. Overlay the eSAIL® "envelope"—from the sealed base flange up to the start of the suction zone—onto this model.
3. **Identification of ATEX-Free Installation Positions**
    a. Search for deck locations where the **suction inlet** remains entirely outside any ATEX zone.
    b. Generate a shortlist of candidate positions, evaluating each one of them in terms of:
        i. Cargo handling operations (loading/unloading clearances)
        ii. Crew passageways and emergency-escape routes
        iii. Interference with other deck equipment
4. **Mitigation Proposals (if no ATEX-free locations exist)**
    a. Propose **relocation of deck components** (e.g., PV valves, vent headers, manifolds) to create ATEX-free zones.

   b. Coordinate these proposals with the shipowner and classification society to ensure cargo operations and safety are not compromised.

5. **Exception Handling**
   a. **Emergency Stop Button** always requires ATEX certification when installed on the exposed deck (Zone 1 or 2).
   b. **Anemometer**: only requires ATEX certification if its final elevation intersects a hazardous zone; otherwise, a standard marine sensor may be used.
6. **Final Classification Society Approval**
   a. Submit the proposed eSAIL® location(s) and any mitigation measures to the classification society for "Approval in Principle."
   b. Incorporate any feedback or additional requirements before proceeding to detailed structural and electrical design.

By leveraging the vessel's existing Hazardous Area Plan and applying this rigorous methodology, Bound4blue ensures that the eSAIL® system is installed **outside of hazardous zones**, avoiding unnecessary ATEX equipment costs while maintaining full compliance with maritime safety regulations.

5 Safe location of the eSAIL® and Its Integration

Selecting the appropriate installation site for the eSAIL® system is essential to ensure compliance with safety regulations and to optimize technical and economic feasibility. A primary goal is to locate the system outside hazardous (ATEX) zones, thereby avoiding the use of costly ATEX-certified components. This not only reduces equipment and installation costs but also preserves design flexibility and facilitates smoother integration on both retrofit and newbuild vessels.

To support this process, Bound4blue conducts a vessel-specific evaluation that accounts for structural, operational, and regulatory constraints. The following points outline the core considerations and steps involved in determining a safe and practical installation location:

- Evaluation of options for the safe installation of the system.
- Identification of operational and structural restrictions in different vessels.
- Case studies of various vessel types and their optimal layouts.

A key aspect of ensuring a safe and compliant eSAIL® integration is the strategic placement of the system in relation to the hazardous zones of the vessel. The objective is to **avoid the need for ATEX-certified components**, which would otherwise significantly increase costs, limit design flexibility, and reduce the commercial viability of the retrofit or newbuilding installation. To achieve this, the design and engineering teams at Bound4blue conduct a detailed assessment of each vessel's hazardous area layout prior to installation.

5.1 General strategy

The eSAIL® system is designed to be **gas-tight and sealed from the deck interface (connection flange) up to the beginning of the suction zone**, which is the only part of the system that interacts dynamically with ambient air. This inherent design feature allows the system to be treated as **non-hazardous** up to the point of air intake. As a result, by ensuring that **the suction zone remains outside of any hazardous areas**, the entire sail can be integrated without requiring ATEX certification for most of its components.

This strategy has been validated with multiple classification societies and is included as part of the standard engineering package provided to the client.

5.2 Hazardous area study

Each vessel is different in its hazardous zone distribution, depending on its cargo type (e.g., oil, gas, or chemical products) and tank layout. A detailed **hazardous area classification drawing**, usually part of the ship's safety documentation, is used to define:

- Zone 0: areas where explosive atmospheres are continuously present (rare on deck).
- Zone 1: areas where explosive atmospheres are likely to occur during normal operation (e.g., around PV valves).
- Zone 2: areas where explosive atmospheres are not likely to occur but may appear occasionally.

Using this drawing, a **3D layout of the deck and equipment** is created to find suitable locations where the eSAIL® can be installed without overlapping with any of these zones—particularly avoiding any intersection between the **suction zone and Zones 0 or 1**.

5.3 Handling conflicts with hazardous zones

In cases where no suitable zone exists that keeps the suction area fully outside the hazardous region, a **mitigation strategy** is applied. The most common and effective solution is to **relocate deck elements** that define or influence the hazardous zone, such as:

- **Pressure/vacuum (PV) valves**
- **Cargo vent outlets**
- **Manifold areas**

This relocation is always carried out in close coordination with the shipowner and classification society, to ensure that it does not negatively affect cargo operations or compromise safety. When agreed upon, this small rearrangement in deck layout opens a "safe corridor" in which the eSAIL® can be installed without triggering the need for ATEX components.

5.4 Sealing and Internal Integrity

The pedestal structure of the eSAIL® is engineered to be fully **hermetically sealed**, preventing gas ingress into the sail's interior. All electrical equipment (actuators, sensors, control units) located inside the pedestal are therefore considered to be in a **non-hazardous internal atmosphere**, and are **not required to be ATEX-certified**, even when installed on hazardous deck zones. This containment strategy is a key enabler of the eSAIL®'s compliance flexibility.

6 Required ATEX equipment

While the eSAIL® system is intentionally designed to be installed outside hazardous areas, certain components may still require ATEX certification due to their location or function. In such cases, explosion-proof equipment must be selected and integrated in full compliance with applicable maritime and industrial standards.

This section outlines the key elements that may fall within hazardous zones, the conditions that necessitate ATEX certification, and the procedures followed to ensure proper classification, selection, and documentation. These considerations are critical to safeguarding vessel operations and ensuring regulatory approval.

The following key areas are addressed:

- List of key equipment that must comply with ATEX certification (PLC, motors, brakes, sensors, etc.).
- Electrical protection and emergency disconnect systems.
- Integration with the vessel's monitoring and safety systems.

Although the eSAIL® system is designed to avoid hazardous areas and thereby **minimize the need for ATEX-certified components**, there are specific cases where the installation context makes the use of explosion-proof equipment necessary. This section identifies those components, explains the criteria that make ATEX certification necessary, and outlines the classification and selection process for such equipment in compliance with applicable standards.

Despite all efforts to avoid hazardous zones, two specific components must always be evaluated individually: These, may require ATEX certification depending on the vessel's hazardous area layout:

1. Emergency Stop Button (E-Stop)

- **Location:** Mounted externally at the base of the sail (on the pedestal)
- **Function:** Allows immediate shutdown of the system in case of emergency
- **Justification:** On tankers or gas carriers, the main deck is typically a Zone 1 or Zone 2 hazardous area. Since the E-stop must always be accessible to crew, it is **always exposed to the atmosphere** and **cannot be enclosed within a sealed compartment**.
- **Requirement:** The E-stop is **mandatorily ATEX-certified** and rated for Zone 1. It is selected and supplied in accordance with the relevant explosion-proof standards (e.g., EN 60079 series).

2. Anemometer (Wind Sensor)

- **Location:** Positioned at the top of the sail
- **Function:** Measures wind direction and speed to optimize the eSail’s performance
- **Justification:** While usually located above any hazardous zones, in rare cases—such as vessels with tall hazardous zone envelopes (e.g., LNG carriers with high vent stacks)—the top of the sail may intersect with a Zone 2 area.
- **Requirement:** If the anemometer falls within a hazardous area, it **must be ATEX-certified**. Otherwise, a standard marine-rated model may be used.

All components requiring ATEX certification undergo a detailed selection process involving:

- **Zone classification and temperature class analysis**
- **Manufacturer documentation review**
- **Cross-checking with classification society requirements** (typically included in the project's Hazardous Area Equipment List)
- Inclusion in the **Hazardous Area Installation Plan**, reviewed and approved by the classification society

The relevant documentation includes:

- ATEX/IECEx certificate of conformity
- Declaration of conformity to Directive 2014/34/EU
- Equipment data sheet and installation manual
- Electrical schematic integration with zone marking

This documentation is compiled and delivered to the shipowner and class as part of the **Technical File for Hazardous Area Equipment**.

7 Schematics and diagrams

Visual documentation plays a critical role in validating the safe integration of the eSAIL® system. Technical schematics and system diagrams help demonstrate compliance with hazardous area requirements, support engineering reviews, and facilitate approval by classification societies.

This section presents graphical evidence of risk-area assessments and the planned integration of the eSAIL® with the vessel's systems. These visuals support the conclusions drawn from the ATEX compliance methodology and installation planning.

The following figures are included:

- Illustrations of risk areas and potential locations for the eSAIL® (Figure 1)
- Diagrams showing integration with other vessel systems (Figure 2)

Below is a set of plan excerpts showing the vessel's approved hazardous-area zones with the eSAIL® superimposed on the deck. In each drawing it is possible to see that the main body of the eSAIL®, including the entire suction-zone envelope, remains completely outside the vertical columns and "bubbles" that delineate the ATEX Zones 1 and 2. These close-up cutouts confirm the selected installation positions and demonstrate full compliance with the ship's Hazardous Area Plan while ensuring maximum operational safety.

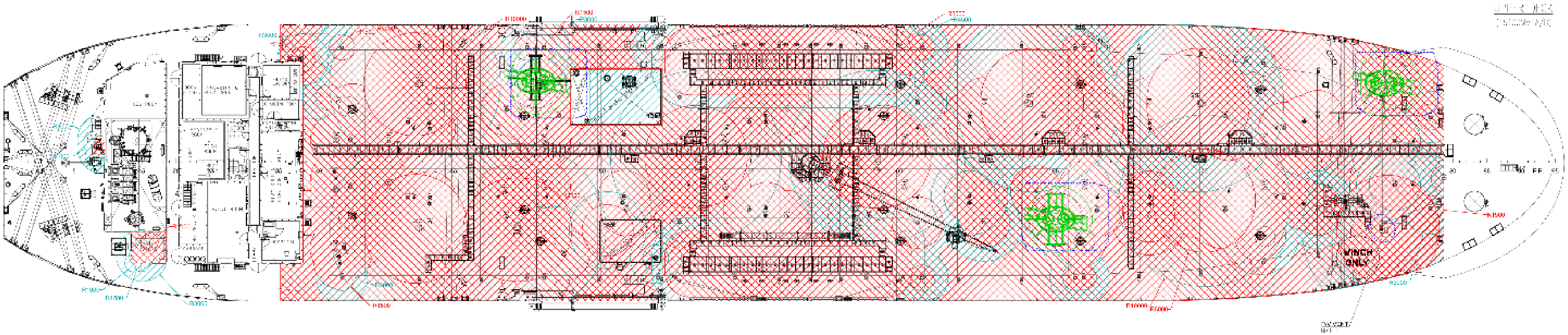

Figure 1: EPSPS hazardous areas drawing (main deck) including eSAILs.

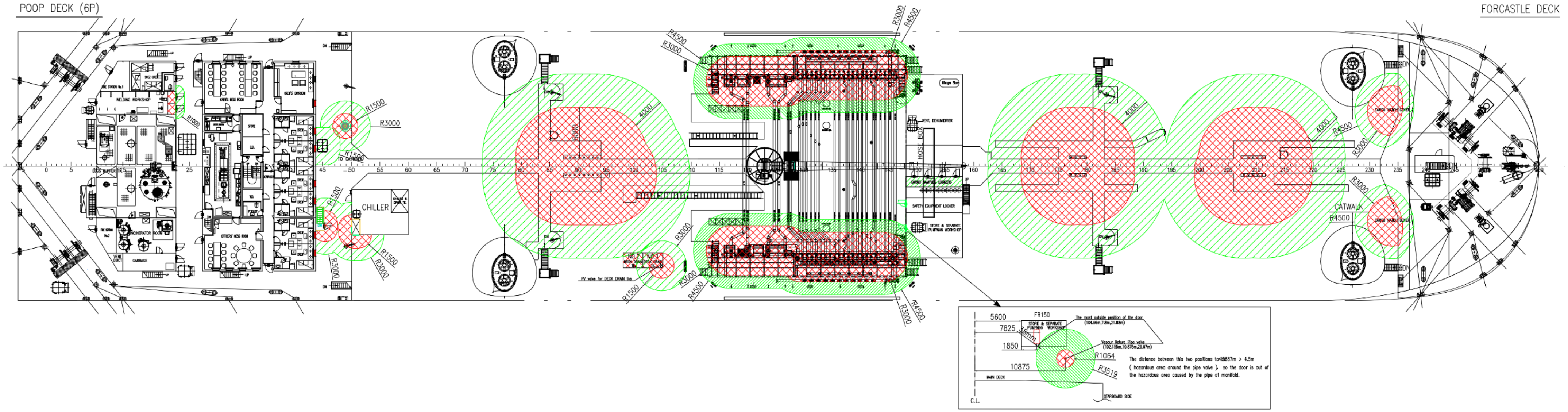

Figure 2: ODFBO hazardous areas drawing (main deck) including eSAILs

8 Closing remarks

The integration of wind-assisted propulsion systems such as eSAIL® represents a transformative step toward decarbonizing maritime operations, offering significant fuel savings and emissions reductions while supporting compliance with evolving international regulations. However, the deployment of such technologies on vessels operating in ATEX-classified environments, where the risk of explosive atmospheres is inherent, presents unique technical and regulatory challenges that must be meticulously addressed to ensure both safety and economic viability.

The installation of equipment in hazardous areas has traditionally required the use of ATEX-certified components. While these components are essential for safety, they can also present significant challenges in terms of capital expenditure and complexity. These requirements can act as barriers to the adoption of innovative propulsion solutions, particularly for tankers, chemical carriers, and gas vessels where hazardous zones are extensive and unavoidable.

A key finding of this report is that a practical strategy exists by conducting a meticulous study of the vessel's hazardous area classification and carefully designing the arrangement and installation of sails, it is possible to position both the sails and their access points outside classified zones. This approach allows for the use of non-ATEX-certified equipment, dramatically reducing installation costs and complexity without compromising safety or regulatory compliance. Case studies demonstrate that such installations have already achieved substantial operational and environmental benefits, with reduced downtime and attractive payback periods.

The success of this strategy hinges on a rigorous process of risk assessment, detailed mapping of hazardous zones, and close collaboration with classification societies and regulatory authorities. By leveraging the vessel's approved Hazardous Area Drawing and integrating best practices for risk mitigation, shipowners can unlock the potential for wind-assisted propulsion even in environments previously considered prohibitive. This not only accelerates the pathway to decarbonization but also broadens the scope of vessels that can benefit from advanced sail technologies.

In summary, while ATEX-certified installations remain indispensable for certain applications, a thorough and strategic approach to hazardous area classification and sail arrangement offers a viable, safer, and more economical pathway for the widespread adoption of wind propulsion systems in the maritime sector. This methodology not only supports the industry's environmental objectives but also ensures that safety remains paramount, paving the way for innovation in even the most challenging operational contexts.

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